TABLE OF CONTENTS

CHAPTER	TITLE	PAGE
	ACKNOWLEDGEMENT	**iv**
	ABSTRACT	**v**
	ABSTRAK	**vi**
	TABLE OF CONTENTS	**vii**
	LIST OF TABLES	**x**
	LIST OF FIGURES	**xii**
	LIST OF SYMBOLS	**xvi**
	LIST OF NOTATION	**xviii**
	LIST OF ABBREVIATION	**xix**
	LIST OF APPENDICES	**xx**
1	**INTRODUCTION**	**1**
	1.1 Research Background	1
	1.2 Problem Statement	2
	1.3 Research Objective	3
	1.4 Research Significance	3
	1.5 Research Scope	4
	1.6 Organisation of the Writing and Terminologies	4
2	**LITERATURE REVIEW**	**6**
	2.1 Background on Composite Construction	6
	2.2 One-way Local Buckling Due to Intimacy Contact with Concrete	8
	2.2.1 Previous Researches Related to One-way Local Buckling	11
	2.3 Foundation	13
	2.3.1 Previous Researches Related to Pad Footing	14
	2.3.2 Design Situation and Failure Mode of Pad Footing	18

2.4 Development of Pre-fabricated Pad Footing 19
2.5 Concluding Remarks 20

3 EXPERIMENTAL AND THEORETICAL ASPECTS OF PAD FOOTING 21
3.1 Specimens and Materials Details 21
3.2 Structural Aspects of Pad footing 28
3.2.1 Design of the Proposed Pre-fabricated Pad Footing 29
3.2.1.1 Design of Stump 31
3.2.1.2 Design of Case 1 Specimen (T.1510) 33
3.2.1.3 Design of Case 2 Specimen (A.1510) 37
3.2.1.4 Design of Case 3 Specimen (C.1510) 41
3.2.1.5 Summary of Design Calculation 46
3.3 Preparation of Specimens 49
3.4 Experimental Tests Setup and Procedures 52
3.5 Data Acquisition 55
3.6 Concluding Remarks 56

4 RESULTS AND DISCUSSION 57
4.1 Experimental Results and Failure Modes of Specimens 57
4.2 Case 1: Conventional Pad Footings 58
4.3 Case 2: CFS + A10 Wire Mesh Pad Footings 66
4.4 Case 3: Fully CFS Pad Footings 71
4.5 Performance Comparison 83
4.5.1 Effect of adding CFS as Permanent Formwork 83
4.5.2 Effect of Substituting CFS to Replace Mesh Reinforcement 84
4.5.3 Effect of Increasing CFS Section Size to Have Thicker Pad Depth 86
4.6 Standardised Table of the Proposed Pre-fabricated Pad Footing 86
4.7 Design Example using Standardised Table 96
4.8 Summary of Results 96

5 CONCLUSIONS 98

5.1 Summary of Thesis 98

5.2 Conclusions 99
5.3 Recommendation for Future Research 100

REFERENCES **101**

APPENDICES A-C **106-140**

LIST OF TABLES

TABLE NO.	TITLE	PAGE
3.1	Summary: Tested and designed material strength for specimens	26
3.2	Summary: Measured dimension for specimens	26
3.3	Details of the specimens	28
3.4	Four design aspects of pre-fabricated composite pad footing	29
3.5	Stump design worksheet	32
3.6	Specimen T.1510 design worksheet	34
3.7	Specimen A.1510 design worksheet	37
3.8	Specimen C.1510 design worksheet	42
3.9	Case 1 specimens calculation summary	47
3.10	Case 2 specimens calculation summary	47
3.11	Case 3 specimens calculation summary	47
4.1	Test results of Case 1 Specimens	58
4.2	Test results of CFS + A10 wire mesh Pad Footings	66
4.3	Test results of Fully CFS Pad Footings	73
4.4	Performance comparison of Case 1 specimens *vs* Case 2 specimens	84

4.5	Comparison of load capacity of Case 2 specimens *vs* Case 3 Specimens	85
4.6	Steel reinforcement area and the strength performance increment	85
4.7	Strength performance increment resulted from section size increment	86
4.8	Summary of the presumed allowable bearing values (BS 8004:1986)	87
4.9	Calculated strengths of pre-fabricated composite pad footings	89
4.10	Calculation of specimen's bearing capacity.	91
4.11	Standardised Table for CFS pre-fabricated composite pad footing, sheet 1	92
4.12	Standardised Table for CFS pre-fabricated composite pad footing, sheet 2	93
4.13	Standardised Table for CFS pre-fabricated composite pad footing, sheet 3	94
4.14	Standardised Table for CFS pre-fabricated composite pad footing, sheet 4	95
4.15	Example design worksheet using Standardised Table	96

LIST OF FIGURES

FIGURE NO.	TITLE	PAGE
2.1	Badir-Razali building system classification	7
2.2	One-way local buckling due to intimate contact with rigid medium	8
2.3	Assumed buckling shapes for outstanding flanges subject to uniform compression formulated by Wright (1995)	10
2.4	Types of shallow foundation	14
2.5	Experimental test setup of Hallgren *et al.* (1998).	15
2.6	Test setup of rigid footing by Chung and Cascante (2007).	16
2.7	Test setup of Hegger et al. (2007).	17
3.1	Illustration of (a) Case 1 specimen, (b) Case 2 specimen, (c) Case 3 specimen	22
3.2	The cubes cast for the cube tests	23
3.3	The cubes, size 150 mm, prepared for the cube tests	24
3.4	The TONIPAC 300 Testing Machine used for cube tests	24
3.5	The samples for tensile and coupon tests	25
3.6	Conventional graph generated from one of the tensile tests	25
3.7	Distribution of pressure for different soil type, Mosley *et al.* (1999)	29
3.8	Column detailing	33

3.9	Critical zone of specimen T.1510	33
3.10	Failure zone of specimen A.1510	37
3.11	Failure zone of specimen C.1510	42
3.12	Detailing drawing for Case 1 specimens – T.1510	48
3.13	Detailing drawing for Case 2 specimens – A.1510	48
3.14	Detailing drawing for Case 3 specimens – C.1510	49
3.15	The pre-fabricated frame drawing for specimen C.1512	50
3.16	A Case 1 specimen before casting work	51
3.17	The specimens during casting work	51
3.18	Occurrence of maximum moment at the face of the column	52
3.19	Setup of the test (Larger Drawing in Appendix C)	53
3.20	DARTEC test rig used for the experimental tests	54
3.21	Flow of data acquisition.	55
4.1	Specimen T.1510 : flexure bending mode of failure	59
4.2	Specimen T.1512 : flexure bending mode of failure	59
4.3	Specimen T.1515 : flexure bending mode of failure	60
4.4	Specimen T.1517 : flexure bending mode of failure	60
4.5	Specimen T.1510P : punch failure with radial yield lines	61
4.6	Specimen T.1512P : punch failure with radial yield lines	61
4.7	Specimen T.1510 : Load-Displacement	62
4.8	Specimen T.1512 : Load-Displacement	62

4.10	Specimen T.1517 : Load-Displacement	63
4.11	Specimen under punch test setup	64
4.12	Specimen T.1510P : Load-Displacement	65
4.13	Specimen T.1512P : Load-Displacement	65
4.14	Specimen A.1510 : punching mode of failure	67
4.15	Specimen A.1512 : punching mode of failure	68
4.16	Specimen A.1515 : punching mode of failure	68
4.17	Specimen A.1517 : punching mode of failure	69
4.18	Specimen A.1510 : Load-Displacement	69
4.19	Specimen A.1512 : Load-Displacement	70
4.20	Specimen A.1515 : Load-Displacement	70
4.21	Specimen A.1517 : Load-Displacement	71
4.22	Condition at bottom of Specimen C.1510 after punch failure	72
4.23	Specimen C.1510 concrete rubbles left after test	73
4.24	Specimen C.1510 : Load-Displacement	74
4.25	Specimen C.1510 : punching mode of failure	74
4.26	Specimen C.1512 : Load-Displacement	75
4.27	Specimen C.1512 : punching mode of failure	75
4.28	Progression of failure mode indicates strength improvement	76
4.29	Specimen C.1515 : Load-Displacement	76
4.30	Specimen C.1515 : flexure bending mode of failure	77

4.31	Specimen C.1517 : Load-Displacement	77
4.32	Specimen C.1517 : flexure bending mode of failure	78
4.33	Specimen C.2010 : Load-Displacement	78
4.34	Specimen C.2010 : punching mode of failure	79
4.35	Specimen C.2012 : Load-Displacement	79
4.36	Specimen C.2012 : punching mode of failure	80
4.37	Specimen C.2015 : Load-Displacement	80
4.38	Specimen C.2015 : flexure bending mode of failure	81
4.39	Specimen C.2017 : Load-Displacement	81
4.40	Specimen C.2017 : flexure bending mode of failure	82
4.41	Maximum load *vs* maximum deflection of all specimens	83
4.42	Flow-chart : Structural design using the Standardised Table	88

LIST OF SYMBOLS

A_c	-	Cross section area of concrete
A_{cc}	-	Column Area
A_{pad}	-	Pad Area
A_{sb}	-	Cross section area of steel at major axis
A_{sc}	-	Cross section area of steel reinforcement in compression
A_{sca}	-	Cross section area of CFS used as reinforcement
A_{scb}	-	Cross section area of CFS used as formwork
A_{sw}	-	Cross section area of steel at minor axis
A_s	-	Cross section area of steel reinforcement in tension
b	-	Pad Breadth
b_v	-	Section breath of the pad
c	-	Thickness of concrete nominal cover
cc_x	-	Breadth of column
cc_y	-	Width of column
c_{sc}	-	Centroid of CFS
c_{sca}	-	Centroid of CFS used as formwork
c_{scb}	-	Centroid of CFS used as reinforcement
d	-	Effective depth of the pad
D	-	Height of CFS
D_a	-	Height of CFS section used as formwork
D_b	-	Height of CFS section used as reinforcement
d_c or d_{CFS}	-	Effective depth of outer CFS
F	-	Flange measurement of CFS
F_{ya}	-	Force act on left resulted from applied axial load
F_{yb}	-	Force act on right resulted from applied axial load
f_{cu}	-	Characteristic strength of concrete
f_y	-	Characteristic strength of steel

f_{yc}	-	Characteristic strength of CFS
G_k	-	Characteristic dead load
h	-	Pad Height
K	-	Factor based on simplified stress block
L	-	Pad Length
M	-	Moment
M_x	-	Moment acting on major axis
M_y	-	Moment acting on minor axis
N	-	Axial load
P	-	Pressure
p_y	-	Design strength of steel
Q_k	-	Characteristic imposed load
S_v	-	Spacing between link bars placement for stump/column
t	-	Steel Thickness
U	-	Critical parameter, 1.5d away from the stump/column
U_o	-	Stump/Column perimeter
w	-	Pad Width
V	-	Design shear force due to ultimate loads
v_c	-	Design concrete shear stress
v_{max}	-	Maximum design shear stress
z	-	Lever arm
%	-	Percent
=	-	Equals to
+	-	Plus, or Mathematical operator: plus
−	-	Dash, or Mathematical operator: minus
×	-	Mathematical operator: multiply
÷ or /	-	Mathematical operator: divide
^	-	Mathematical operator: to the power of
√	-	Mathematical operator: square root of
π	-	Pi = 3.14159
γ_m	-	Partial safety factor for concrete
$Ø_{bar}$	-	Diameter of steel bar reinforcement
$Ø_{min}$	-	Minimum required diameter of steel reinforcement.

LIST OF NOTATION

A10	-	Wire mesh, diameter 10 mm and spacing 200 mm × 200 mm
A.1510	-	Case 2 specimen label. A indicating A10 wire mesh; first and second digits reflect thickness of pad,15 = 150 mm; third and fourth digits reflect breadth of pad, 10 = 1000 mm
C.1510	-	Case 3 specimen label. C indicating fully CFS; first and second digits reflect thickness of pad,15 = 150 mm; third and fourth digits reflect breadth of pad, 10 = 1000 mm
C25	-	Grade of concrete: 25 N/mm^2 characteristic strength
C35	-	Grade of concrete: 35 N/mm^2 characteristic strength
$F_{V\ 1.0d}$	-	Loading when shear failure happens at 1.0d away from stump/column face
$F_{V\ 1.5d}$	-	Loading when punch failure happens at 1.5d perimeter away from column face
$F_{V\ max}$	-	Loading when punch failure happens at stump/column Perimeter
$F_{Mx\ max}$	-	Loading when failure happens due to bending moment
KS10016C	-	Name of CFS section, refer to Table 3.1 and Table 3.2
KS15016C	-	Name of CFS section, refer to Table 3.1 and Table 3.2
KS20016C	-	Name of CFS section, refer to Table 3.1 and Table 3.2
R6	-	Stump/Column link bars with 6 mm diameter
T10	-	Stump/Column reinforcement bar with 10 mm diameter
T.1510	-	Case 1 specimen label. T indicating conventional; first and second digits reflect thickness of pad,15 = 150 mm; third and fourth digits reflect breadth of pad, 10 = 1000 mm

LIST OF ABBREVIATION

BS	-	British Standard
BSI	-	British Standard Institution
CFS	-	Cold-formed Steel
CIDB	-	Construction Industry Development Board Malaysia
IBS	-	Industrialised Building System
kN	-	Unit of measurement: kilo Newton
max	-	maximum
min	-	minimum
mm	-	Unit of measurement: millimeter
mm^2	-	Unit of measurement: millimeter square
MPa	-	Unit of measurement: Mega Pascal, equivalent to N/mm^2
N	-	Unit of measurement: Newton
N/mm^2	-	Unit of measurement: Newton per millimeter square, equivalent to MPa
vs	-	Versus

LIST OF APPENDICES

APPENDIX	TITLE	PAGE
A	Supplementary Tests Worksheets	106
B	Specimens Design Calculation Worksheets	109
C	Fabrication Drawings for Specimens and Test Setup Drawing	137